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DEVELOPMENT AND QUALIFICATION OF INITIATOR, XM100

George P. Catrambone

Frankford Arsenal
Philadelphia, Pennsylvania

September 1969

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Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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NOTICE

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FOREWORD

The work described in this report was performed by Frankford Arsenal, U.S. Army Munitions Command, Philadelphia, Pennsylvania, for the Life Support Program Office (ASWL), Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, under MIPR AS-7-181. Captain C. Cordova, ASWLF, was the project manager, and Mr. P. Mullen, ASNMC-10, was the project engineer.

The development work was performed by the Propellant Actuated Devices Laboratories, Ammunition Development and Engineering Laboratories, Frankford Arsenal, with G. P. Catrambone, Development Engineering Branch, as the responsible project engineer. The ballistic test program was performed under the direction of R. H. Bagwell, of the Ballistics Laboratories. Inclusive dates of the program were February 1967 to September 1968.

This report was submitted by the author on 17 July 1969.

This technical report has been reviewed and is approved.

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ABSTRACT

This report describes the development and qualification of the XM100 Initiator. The XM273 Impulse Cartridge is contained in the initiator and, when fired, provides a pressure output of approximately 1500 psig at -65° F with 15 feet of Teflon #4 size hose. The maximum pressure obtained when fired with one-half foot of hose at 200° F is approximately 6000 psig.

The initiator incorporates a simplified firing mechanism that is mechanically actuated. In addition to the normal bulkhead mounting, the initiator has a universal bracket that offers greater flexibility for mounting than designs presently in use.

The qualification results established that the XM100 Initiator satisfied all performance requirements and its ballistic characteristics were reproducible with respective hose lengths.

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INTRODUCTION

The demands placed on the performance of initiators are ever increasing and to satisfy some of these demands the XM100 initiator was developed. The original program for the XM100 initiator* was directed primarily to improving the critical components to realize a substantial contribution to the manufacturing and physical performance of the initiator. At the completion of this effort, several major improvements were incorporated in the design. The results of the design objectives were favorable; however, further development before qualification was considered necessary, particularly in the area of cartridge development.

In the initial cartridge (XM189) development, the approach was primarily based on an extruded cartridge case and the utilization of the cold-weld principle to accomplish the hermetic seal requirement. However, after evaluating the test results, it appeared to be more advantageous to modify an existing cartridge rather than pursue the original concept.

This report summarizes the work performed during the cartridge development and qualification phases of the XM100 initiator. Figure 1 illustrates the cross section, envelope dimensions, and assembly of the XM100 initiator, while Figure 2 is a view of the disassembled initiator.

DESIGN PARAMETERS

Cartridge

1. Dimensions: The cartridge over-all dimensions could not exceed the space limitation of the XM100 initiator.

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*G. P. Miller, "Design Improvement of High Temperature Initiator Designated 'Initiator, Cartridge Actuated: XM100'," Frankford Arsenal Report R-1780, November 1965.

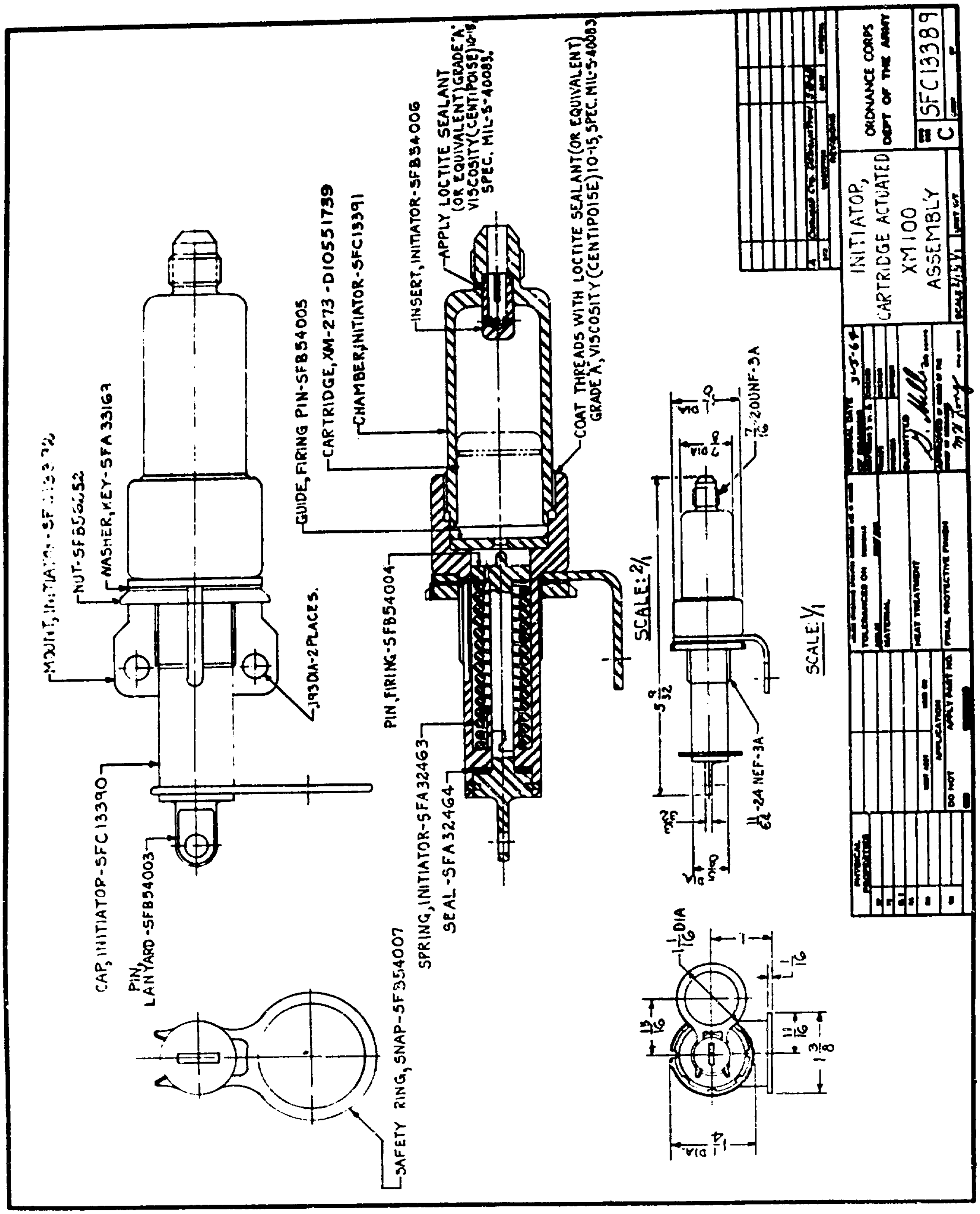
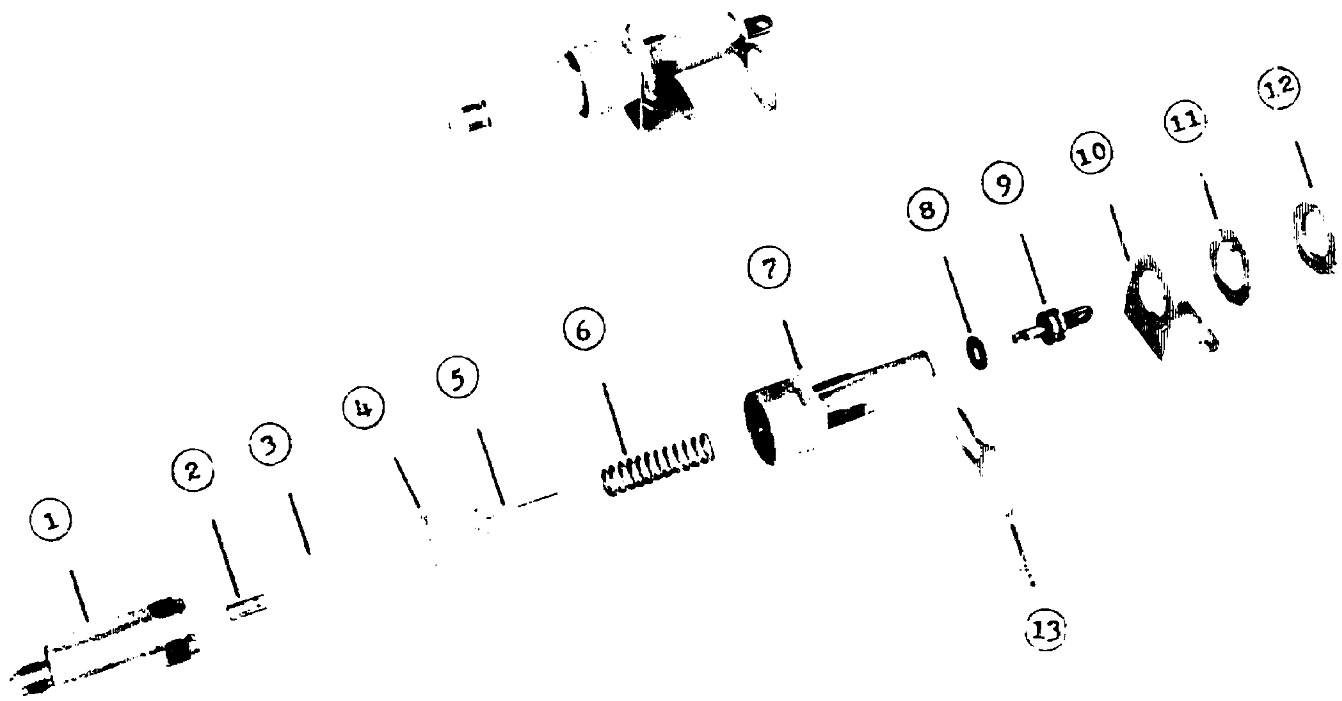


Figure 1 Assembly drawing, XM100 Initiator



1.	Chamber	5.	Pin, Firing	10.	Mount
2.	Filter Insert	6.	Spring	11.	Lock Washer
3.	Cartridge, XM273	7.	Cap	12.	Lock Nut
4.	Guide, Firing Pin	8.	Seal	13.	Safety Snap Ring
		9.	Lanyard Pin		

Figure 2. Disassembled view, XM100 Initiator

2. Configuration: It was mandatory that the design of the cartridge case incorporate a flat head for compatibility with corresponding surfaces in the XM100 initiator chamber.

3. Ballistic Performance:

a. A minimum pressure of 1000 psi at -65° F through 15 feet of Teflon hose, #4 size (MIL-H-25579), to a terminal pressure chamber consisting of 0.062 in.^{3} volume.

b. A maximum pressure of 8000 psi at 200° F through 6 inches of Teflon #4 size hose, to a terminal pressure chamber consisting of 0.062 in.^{3} volume.

Initiator

The complete design requirements for the XM100 initiator are contained in Appendix I.

CARTRIDGE DEVELOPMENT

As stated in the INTRODUCTION, it was decided to replace the XM189 cartridge of the XM100 initiator with a cartridge of a different design since it was determined that deficiencies in the cold-weld technique used to seal the XM189 cartridge produced unreliable ballistic results. Also, the erosion characteristics of the potassium perchlorate propellant and the excessive residue contributed directly to the erratic ballistic results noted during the preliminary testing. The additional time and funding required to further perfect the technique were not within the scope of the subject program.

A survey was conducted which resulted in the selection of the XM225 type cartridge as a prime candidate. This cartridge is similar to the XM189 cartridge in that it features an extruded case with a flat head. Past performance of the XM225 cartridge demonstrated that the closure disc rupture was reproducible. A decision was therefore made to further evaluate this cartridge for use in the XM100 initiator.

Prior to establishing a propellant charge to meet the performance requirements, a study was performed to find a suitable substitute for the potassium perchlorate used initially with the cold-welded cartridge. Boron potassium nitrate ($BKNO_3$) was selected because of its previous success in a similar application.*

Once it has been determined that the free volume of the cartridge would permit sufficient loading to provide the maximum energy, the charge establishment phase commenced. Several cartridges were assembled with pelletized $BKNO_3$. The average 2D size pellet weight is 0.150 gram, with a density of 1.82 gm/cc. The pellet shape is cylindrical with convex ends, similar to an aspirin tablet, and the diameter and length of these pellets are approximately 1/4 inch x 1/8 inch, respectively. The cartridges were assembled in test initiators and fired into 1/2 and 15 feet of hose for the purpose of establishing ballistic and mechanical performance.

After analyzing the exploratory test results, some pressure dispersion was noted upon examination of the fired cartridges. It was concluded that the dispersion was attributable to the following:

1. The material hardness for the closure disc was found to be higher than recommended while the case hardness at the crimped end was less than specified. Consequently, the closure disc did not rupture as designed; the crimp unrolled, permitting the disc to be displaced intact.

2. The tests conducted under extreme conditions (i.e., firing at 200° F into one-half foot of hose coupled to a 0.062 in.^{3} pressure block) demonstrated that the structural integrity of the primer (the M29A1) was inadequate for this application.

To correct the above deficiencies the following actions were taken:

*Eugene J. Doebley, "Development and Qualification of the XM98 Initiator," Frankford Arsenal Report R-1761, May 1965.

1. The cartridge case crimp area and closure disc were heat treated to obtain the desired mechanical properties.

2. The M29A1 primer was replaced with the 72M primer. Its replacement was possible since the firing mechanism of the XM100 initiator was designed to deliver 120 inch-ounces, twice the energy required for the 72M primer. Table I shows corresponding data for both primers.

TABLE I.
Data, Percussion Primers

Designation	Dimensions (in.) O.D.	Length	All-fire Energy (in.-oz)	Specification MIL-P	Cup Base Thickness (in.)
M29A1	0.205	0.115	18	2496	0.010
72M	0.212	0.125	60	749E	0.027

A small qunatity of modified cartridges was assembled with 13, 15, and 17 (2D) pellets and fired to evaluate the design modifications and to conduct exploratory charge development. Ballistic data obtained from these firings are tabulated in Table II.

The fired cartridges were removed from the initiators and examined for closure disc rupture and primer erosion. There was no evidence that the crimp unrolled nor were there signs of erosion with the 72M primer. It is apparent from the data that 13 pellets of $BKNO_3$ generated insufficient gas pressure to satisfy the minimum performance requirement (1000 psi) at -65° F with 15 feet of hose. When a statistical summary of all the firings was computed, it appeared that the 15-pellet charge would be marginal. The 17-pellet charge appeared to meet the performance requriement.

In order to evaluate the structural integrity of the devices incorporating the design modifications, five cartridges were loaded with 19 pellets, representing the maximum charge that could be loaded in the cartridge volume. These cartridges were then fired

TABLE II.
Data, Exploratory Test

Round No.	Firing Temp (°F)	Propellant Charge (No. of Pellets)	Hose Length (ft)	Max Pressure (psi)	Time to pmax (sec)[a]
1	200	13	0.5	4310	0.042
2	200	13	0.5	4110	0.037
3	200	13	0.5	4090	0.039
4	-65	13	15.0	970	0.044
5	-65	13	15.0	955	0.039
6	-65	15	15.0	1290	0.039
7	-65	15	15.0	1230	0.040
8	200	17	0.5	5860	0.037
9	200	17	0.5	5720	0.043

[a] Time to pmax is elapsed time from first continuous rise on pressure trace to maximum pressure point.

locked-shut at +200° F to obtain pressures in excess of the regular charge. Upon examination after the firings it was noted that there was no evidence that the primer eroded nor was the structual integrity of the XM100 initiator adversely affected.

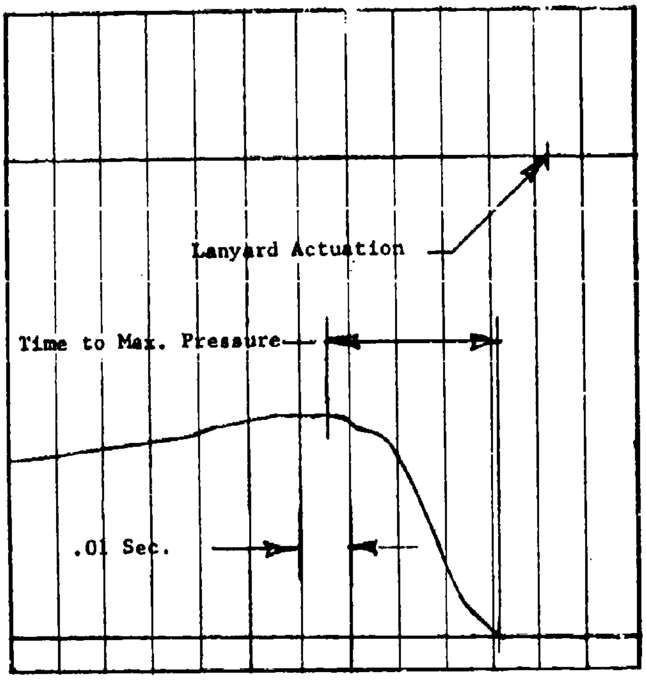
Based on the analysis of the aforesaid test, a verification test program to check the general functioning of the initiators and cartridges was conducted. This program consisted of 35 development tests; 10 firings were conducted at +200° F with one-half foot of hose, 15 firings at -65° F with 15 feet of hose, and 10 firings (5 with one-half foot of hose and 5 with 15 feet of hose) at +70° F. All the cartridges were loaded with 17 pellets of $BKNO_3$ (2D size). The pressure was delivered through Teflon hose to a terminal pressure chamber having a volume of 0.062 cu in. Table III summarizes the engineering design test data.

TABLE III.
Summary of Engineering Design Tests

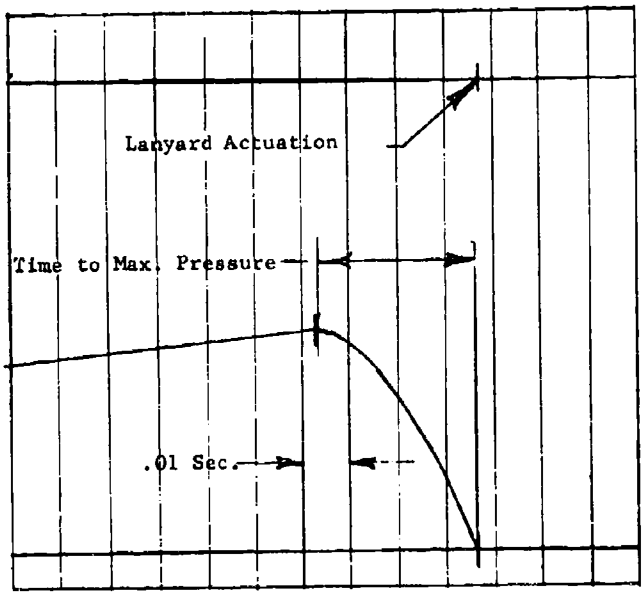
No. of Firings	Firing Temp (°F)	Hose Length (ft)	Average Pressure (psig)	Time to Average Pressure (sec)
15	-65	15.0	1555	0.038
10	+200	0.5	5788	0.036
5	+70	15.0	1605	0.035
5	+70	0.5	5750	0.038

Round by round results of these tests are presented in Appendix II. Figure 3 illustrates typical pressure-time for these test conditions.

It is apparent from the performance that the charge weight selected (17 pellets, 2D size, of $BKNO_3$) meets the ballistic requirements. The nomenclature assigned to this cartridge assembly is "Cartridge, Impulse: XM273." An assembly drawing for the XM273 cartridge is shown in Figure 4.



15 ft. Hose Assembly, Conditioned at -65°F



0.5 ft. Hose Assembly, Conditioned at 200°F

Figure 3. Typical Pressure-Time Traces for the XM100 Initiator

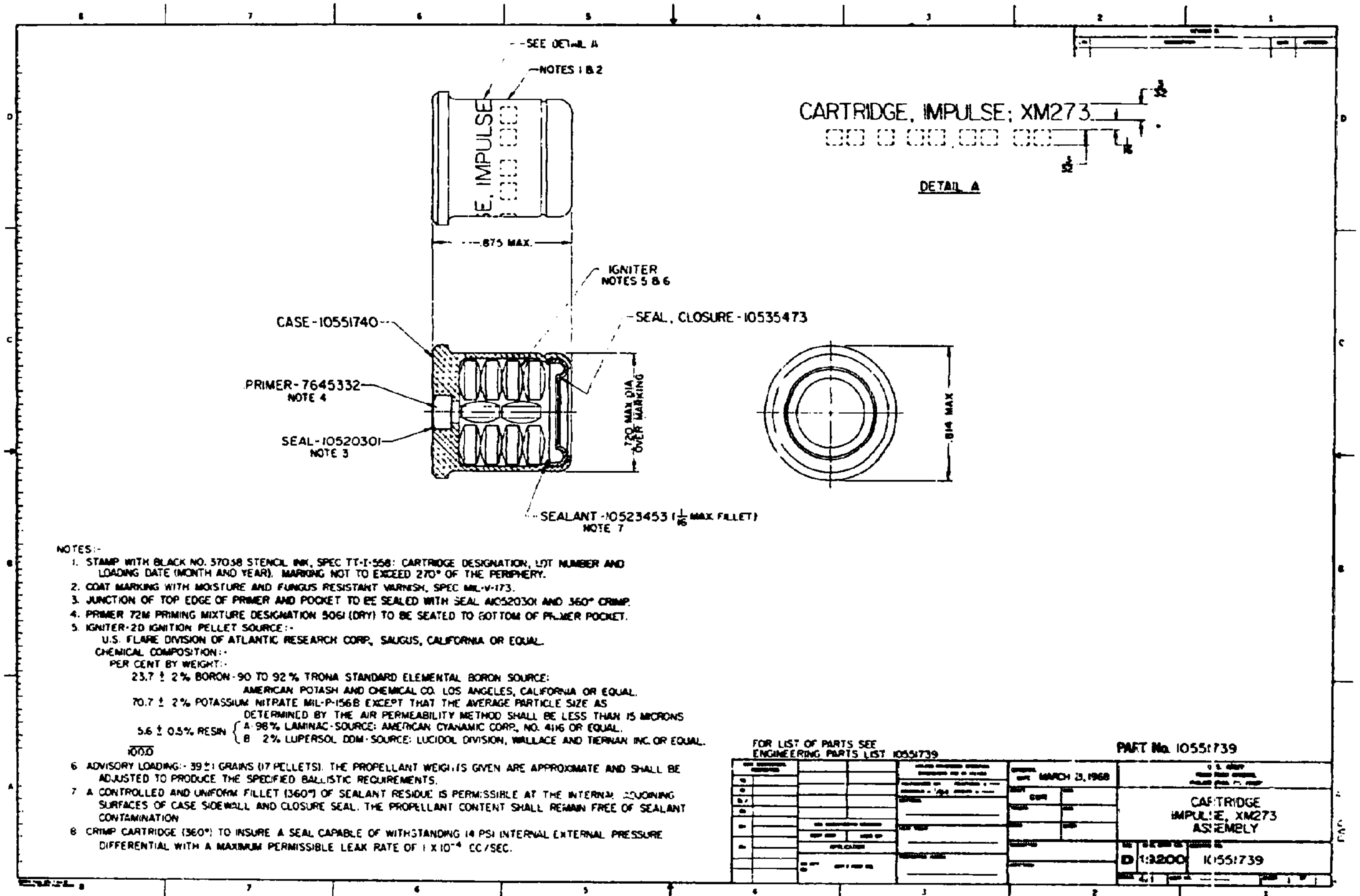


Figure 4. Assembly drawing, XM273 Impulse Cartridge

QUALIFICATION TEST PROGRAM

A 125-pound engineering test program was prepared consisting of 90 performance firings, 15 environmental firings, and 10 locked-shut and 10 ignition firings at -90° F.

Table IV presents an environmental plan to provide assurance that the initiator would meet the environmental requirements. The environmental tests were applied to the initiators in the sequence indicated.

Air Tightness

All cartridges assembled for the development and qualification tests were subjected to a dry leak test of sufficient sensitivity to ascertain that none of the cartridges leaked in excess of 1 x 10^{-4} cc/sec requirement.

X-ray

Each cartridge was subjected to x-ray examination. X-ray photographs of assembled cartridges were examined to determine compliance with applicable drawings. No defects were found in the cartridges examined.

In the following paragraphs, each test phase performed is summarized. The same six initiators were used for each test. The performance test for ballistic comparison was conducted at the conclusion of the program.

TABLE IV.
Environmental Tests

Test	Method (per MIL-STD-810B)	Assembled Units Required	Remarks
Temperature shock	503 - Procedure 1	6	Use 200° F in lieu of 160° F.
High temperature	501 - Procedure 1	6	Use 200° F in lieu of 160° F.
Low temperature	502 - Procedure 1	6	
Salt fog	509 - Procedure 1	6	
Sand and dust	510 - Procedure 1	6	Use 200° F in lieu of 160° F.
Temperature-Humidity-Altitude	518 - Procedure 1	6	Note 1. After 5 cycles, maintain temperature at 70° F for 2 days, then conduct 5 more cycles before removing.
Shock	516 - Procedure 1	6	Note 2.
Vibration	Aircraft Category Table 514 Procedure 1 Part I, II Curve B	6	Resonant and cycling period shall be divided equally among -65°, 70° & 200° F.
Six-foot drop	Note 3	3 w/ inert ctgs	Note 3.

Notes:
1. Fifteen additional cartridges were exposed to the same test.
2. The six loaded assemblies were subjected to all environmental tests except the drop test.
3. Dropped onto a two-inch thick steel plate imbedded in concrete; two units were dropped, once on each end (four drops); one unit was dropped twice with longitudinal axis parallel to steel plate.

Environmental Tests

Temperature Shock

Six assembled initiators were placed in a test chamber, as per MIL-STD-810, Method 503, Procedure 1 except the high temperature was raised to +200° F, to determine what effect the sudden temperature change would have on the complete initiator. The +200° F chamber temperature was maintained for four hours. The initiators were then withdrawn and were immediately placed in a cold chamber reading -65° F for a period of four hours. The hot-cold constitutes one cycle. A total of three cycles was performed. At the conclusion of this test, the initiators were examined and no change was observed.

High Temperature

The purpose of this test was to determine what adverse effect elevated temperature, due to service life or in storage without protective packaging, would have on the initiator. In accordance with the MIL-STD-810 specification, the six initiators were placed in a temperature chamber and raised to +200° F and maintained for a period of 48 hours. The units were then removed and visually inspected. No deterioration was observed.

Low Temperature

This test was performed to determine the ability of the initiators to withstand extended exposure to extreme low temperature. The chamber temperature was lowered to -80° F and the six initiators were maintained at this temperature for 48 hours. The units were visually inspected and no change was noted.

Salt Fog

The salt fog test was conducted to determine the resistance of the initiators to the effects of a salt atmosphere. The units were placed in the test chamber and exposed to a salt spray, in accordance with the MIL-STD-810 specification, for a period of 48 hours. No damaging effects, such as corrosion or salt deposits on the firing mechanism, were noted upon visually examining the initiators.

Sand and Dust

Because of the abrasive characteristics of sand and dust, the initiators were subjected to this test primarily to determine what effects these particles would have on the moving parts. The units were placed in an appropriate chamber and subjected to the specified test. After two hours at +77° F the internal temperature of the test unit was raised to +200° F (instead of the +160° F stated in the MIL-STD-810 specification) and held there for two hours. Viaual inspection of the units was performed after removal, and the operation of the firing mechanism was compared with that under standard ambient conditions. No deficiencies were noted.

Temperature-Humidity-Altitude

The temperature-humidity-altitude test was conducted to determine the effects on the initiators of cycling between low temperature/low pressure and high temperature/high humidity, to simulate conditions while in service. In addition to the six initiators, fifteen XM273 cartridges were also subjected to the specified test. It should be noted steps 2 through 9 of Procedure I were repeated five times and at the completion of the 5th cycle the units were maintained at +70° F for two days. Steps 2 through 9 were then repeated five additional times. The six initiators and 15 cartridges were removed from the chamber and five cartridges were disassembled. A visual inspection showed that all cartridge components and propellants were normal.

Shock

The shock test was performed to determine the structural integrity and performance of the initiator with respect to the mechanical shock that would be expected in handling, transportation, and use in service.

Three shocks in each direction were applied along the three mutually perpendicular axes of the initiators. The six initiators which were mounted on the test fixture were subjected to a shock pulse of 15 g.

Vibration

This test was performed to determine if the construction of the XM100 initiator would withstand the dynamic stresses induced by the vibrations and, also, to determine if the operational performance of the initiator would be affected. A vibration test in accordance with MIL-STD-810 specification, Table V, and Figure 5 was conducted.

TABLE V.
Vibration Time Schedule

Dwell: 1/2 hour at each resonance.

Resonance Dwell		
No. of Resonances	Total Time at Resonance (hr)	Performance: Total Cycling Time (hr)
0	-	3
1	1/2	2-1/2
2	1	2
3	1-1/2	1-1/2
4	2	1

The units were mounted on a fixture and, during the frequency sweep, a resonance condition was noted at 84 cps in the horizontal position. In compliance with the specified time in the

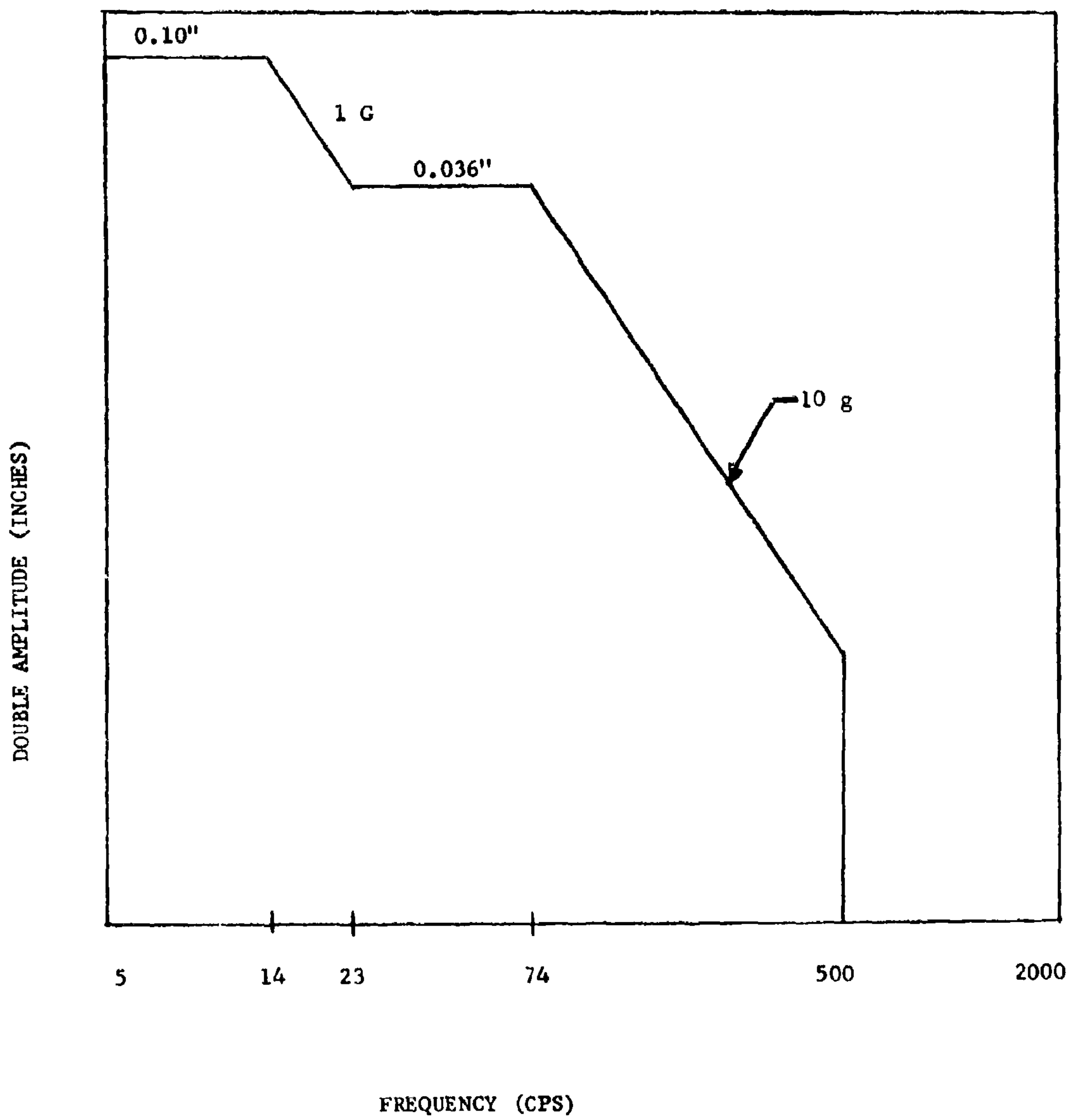


Figure 5. Vibration Test Curve

detailed MIL-STD-810 specification, the initiators remained at this frequency; however, just prior to the one-half hour time requirement, the mounting brackets failed. It was evident by the crack developed at the bend radius of the bracket that it was not capable of withstanding the most severe vibration condition.

The design of the bracket was re-evaluated and both the material and thickness of the bracket were changed. In addition, the bend radius was increased. The material was changed from cold rolled steel (1020) to an alloy steel (4130), and the thickness was increased from 1/16 to 3/32 inch.

The new brackets were manufactured and assembled to the initiators. The units were mounted on the vibrator and the frequency was slowly varied at specified acceleration levels until an individual resonance was observed and recorded at 150 cps (an increase in frequency from the previous 84 cps). Since resonant frequency was encountered, the unit was maintained at this frequency for one-half hours. Subsequent testing then continued along three mutually perpendicular axes at -65°, +70°, and +200° F. At the completion of these tests the initiators were thoroughly inspected and there was no evidence of physical damage.

Six-foot Drop

Three initiators containing inert cartridges were dropped six feet onto a three-inch steel plate imbedded in concrete. Two units were dropped with the gas port striking the slab with the longitudinal axis perpendicular and then dropped so that the lanyard struck the steel plate, for a total of four drops. The third unit was dropped twice with its longitudinal axis parallel to the steel plate.

Inspection of the initiators disclosed the firing pins were not released and there was no evidence of physical damage.

Firing Test Procedure

All ballistic tests were conducted using the same procedure, only the length of hose was varied to satisfy the specified test. A

0.062 cu in. volume pressure chamber was coupled to the terminal end of the specified hose length. The chamber also served to couple the pressure transducer to the system. The transducer was a strain gage type with a zero-to-10,000 psi range and was used in conjunction with a 3000 kc carrier amplifier. An oscillograph was used to record pressure and time. Actuation of the XM100 initiator firing mechanism was accomplished through the use of a solenoid valve. A block diagram of the instrumentation and the physical setup of the test system are presented in Figures 6 and 7, respectively. During the earlier development of the XM100 initiator, an extensive program to evaluate the complete firing mechanism was conducted.

Performance Firings (Environmental Units)

At the completion of the environmental tests, two of the six initiators were disassembled and inspected. No damages or deterioration were noted. The units were reassembled and conditioned at -65° F and then fired.

Five of the 15 additional cartridges that were exposed to temperature, altitude, and humidity were disassembled and inspected for signs of moisture and propellant and primer deterioration. The inspection detected no adverse conditions; therefore, the remaining ten cartridges were fired (5 at -65° F and 5 at +200° F) and their performance was compared with units that had not been subjected to any environmental tests. Results of these firings are presented in Table VI.

The two initiators that misfired were disassembled and the firing mechanism inspected. The cartridges were removed, disassembled, and analyzed. An examination of these cartridges revealed the following.

1. The primer was flush with the cartridge head; however, the primer cup exhibited a flat surface. A microscopic examination of the primer pocket and primer cup revealed that metal from the pocket was forced (or "rolled down") toward the bottom of the pocket thus preventing insertion of the primer to its proper depth. This condition indicates that either the primers were oversize or the pockets were undersize. The other possibility was the insertion of

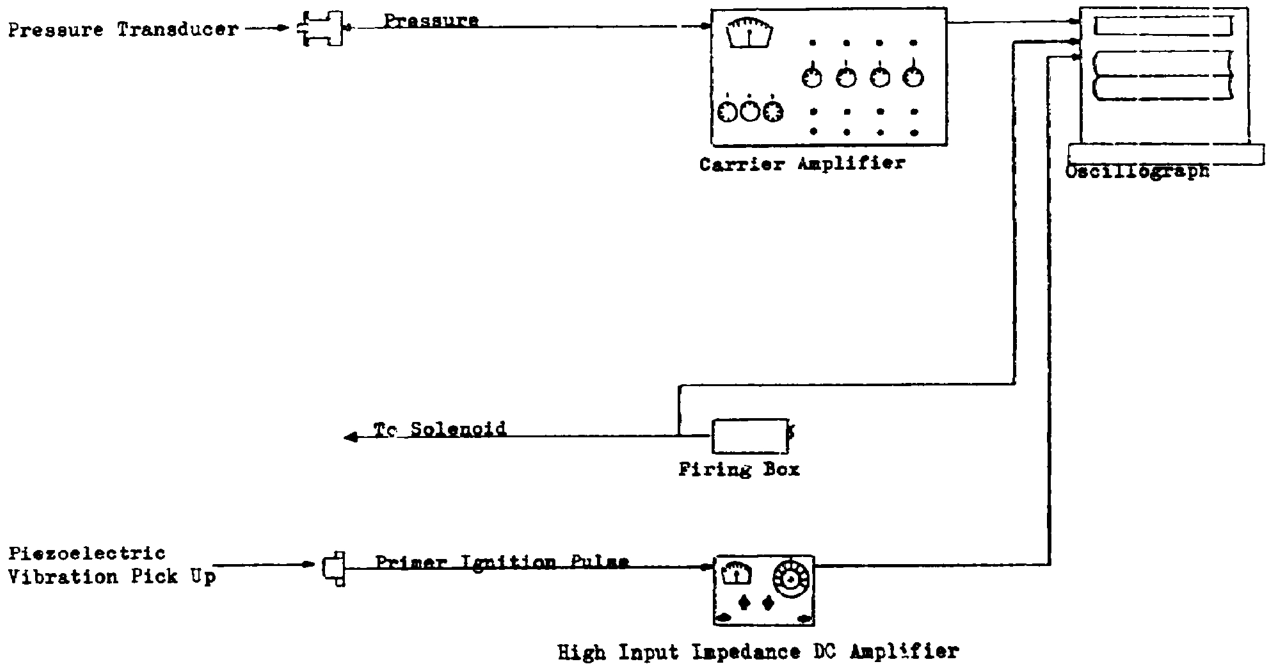


Figure 6. Instrumentation diagram for Initiator Test Firings

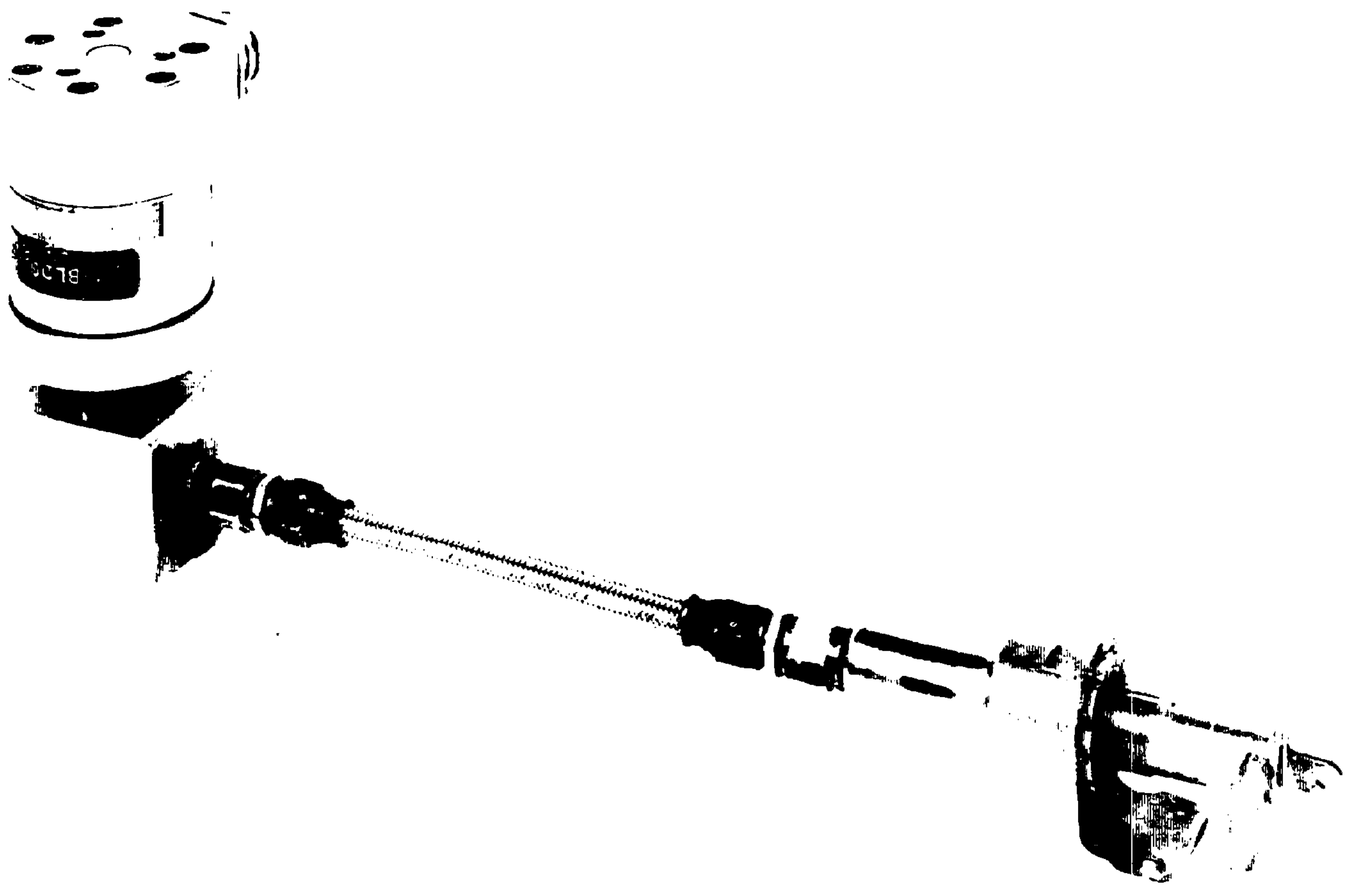


Figure 7. Initiator-Hose Test Setup

TABLE VI.
Data, Environmental Performance Tests

Code: A - Firings conducted with units which had been subjected to the complete environmental program.
B - Firings conducted with cartridges subjected to temperature-humidity-altitude cycling.

Round No.		Length Temperature (° F)	Hose Length (ft)	Max Pressure (psig)	Time to Max Pressure (sec)
A	1	-65	15.0	a	a
	2	-65	15.0	1760	0.032
	3	-65	15.0	1800	0.030
	4	-65	15.0	1960	0.033
	5	-65	15.0	2010	0.032
	6	-65	15.0	a	a
B	1	-65	15.0	1780	0.035
	2	-65	15.0	1670	0.035
	3	-65	15.0	1800	0.035
	4	-65	15.0	1610	0.035
	5	200	0.5	5700	0.033
	6	200	0.5	5810	0.034
	7	200	0.5	5670	0.033
	8	200	0.5	6020	0.031
	9	200	0.5	5740	0.034
	10	-65	15.0	1610	0.034

[a]Misfire

the primer if made with the primers initially in a cocked position. The interface of the primer cup and pocket was such that the primer cup sheared the inside diameter of the primer pocket.

2. The primer indents (resulting from the firing pin striking the primer) were found to be 0.010 and 0.011 inch, respectively.

From these findings it appears the cartridges misfired because the firing pin energy was partially absorbed by the rolled-down metal under the primer, consequently cushioning the blow. The x-ray taken of the test cartridges failed to reveal this faulty primer installation because it was taken primarily to verify presence of components. Such primer failures would not occur in production items since normally two x-ray photographs are taken of each cartridge; one, with the higher intensity, to permit complete viewing of the installed primer and the other, of lesser intensity, for viewing the propellant and closure area.

Ignition Tests at Low Temperature

These tests were conducted to assure that the reliability of ignition at -65° F was not marginal. Ten XM100 initiators were fired after conditioning for four hours at -90° F. All units performed satisfactorily and the test data are presented in Table VII. It should be noted ignition at -90° F was the sole requirement. Instrumentation to record performance and selection of hose length was performed to obtain additional information.

TABLE VII.
Data, Low Temperature Ignition Tests

Round No.	Firing Temperature (° F)	Hose Length (ft)	Max Pressure (psig)	Time to Max Pressure (sec)
1	-90	15.0	1610	0.035
2	-90	15.0	1650	0.035
3	-90	15.0	1480[a]	0.040
4	-90	5.0	3340	0.044
5	-90	5.0	2970	0.044
6	-90	5.0	1400[a]	0.010
7	-90	10.0	2180	0.036
8	-90	10.0	2180	0.036
9	-90	0.5	5610	0.035
10	-90	0.5	5470	0.035

[a]Reduced performance attributed to hose leakage due to repeated use of hose.

Locked-shut Tests

To evaluate the structural integrity of the XM100 initiator, ten units were contitioned, two at -65° F and eight at +200° F. Three of the units fired were previously subjected to drop tests. The initiators were thoroughly examined after the tests and no permanent deformation was observed. Data for these ten firings are presented in Table VIII.

TABLE VIII.
Data, Locked-shut Tests

Round No.	Firing Temperature (°F)	Max Pressure (psig)	Time to Max Pressure (sec)
1[a]	-65	7180	0.034
2	-65	8380	0.033
3	200	10190	0.030
4	200	8490	0.030
5	200	9380	0.029
6	200	8940	0.029
7	200	9150	0.029
8	200	8800	0.030
9[a]	200	9730	0.030
10[a]	200	9030	0.030

[a]Units were previously subjected to drop tests.

Performance Tests

Fifty-five firings were conducted as part of the performance program, and the results are summarized in Table IX.

Round by round rsults of these tests are presented in Appendix III and Figure 8 presents a graph showing mean peak pressure vs hose length.

TABLE IX.
Summary of Qualification Performance Test Data

No. of Firings	Firing Temperature (°F)	Hose Length (ft)	Mean Peak Pressure (lb/in.^{2})	Time To Mean Peak Pressure (sec)
5	-65	15.0	1555	0.033
5	-65	10.0	1350	0.037
5	-65	5.0	3080	0.044
5	-65	0.5	5615	0.038
5	+70	10.0	2320	0.038
5	+70	5.0	3285	0.041
5	+200	15.0	1835	0.032
5	+200	10.0	2240	0.035
5	+200	5.0	3365	0.037
5	+200	0.5	5785	0.033

RELIABILITY ASSESSMENT

The reliability analysis of the XM100 initiator was based on data obtained from the Engineering Design Tests (ED) and the Qualification Tests (QT). Table X illustrates the number and respective test phase, temperature, and hose length, for which the analysis was performed.

A detailed safety statement and instructions for assembly and disassembly of the XM100 initiator are presented in Appendices IV and V, respectively.

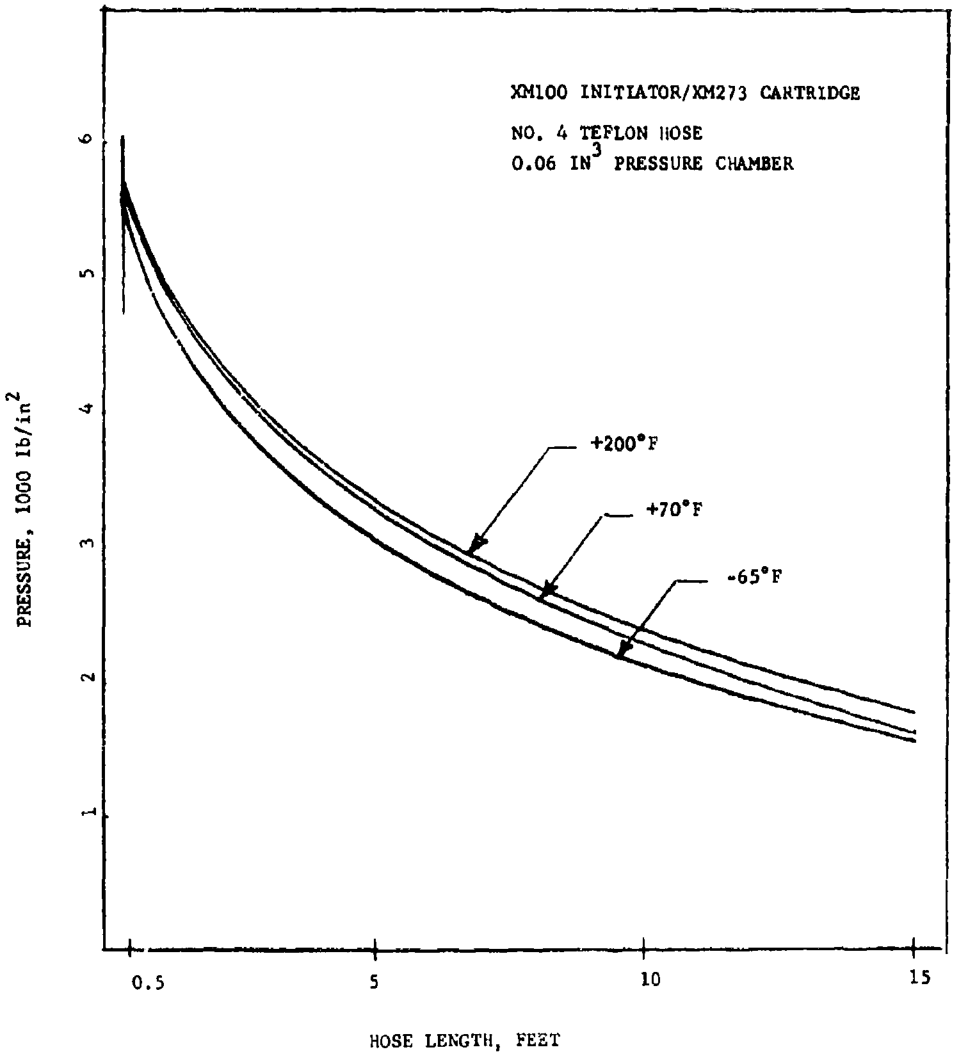


Figure 8. Mean Peak Pressure vs Hose Length at Various Temperatures

TABLE X.
Combined Performance Test Program

Code: ED - Engineering Design Test
QT - Qualification Test

Temperature (°F)	Hose Length			
	0.5 ft.	5.0 ft.	10.0 ft.	15.0 ft.
-65	5 QT	5 QT	5 QT	5 QT 15 ED
+70	5 ED	5 QT	5 QT	5 ED
+200	10 QT 10 ED	5 QT	5 QT	5 QT

The analysis indicated that at the 0.05 level of significance, there was no significant difference between the means or standard deviations for the ED or QT firings. Therefore, combining the ED data and QT data is valid for performing the reliability assessment.

An evaluation of the accumulated data indicates the initiator can be expected to function reliably within the temperature range from -65° to +200° F. It is estimated, based on a total of 90 firings without failure, that the initiator's mechanical firing mechanism has a minimum reliability of 96.6%* with 95% confidence level.

Tables XI and XII summarize the pressure and time data. Table XI includes reliability predictions of the initiator to perform within the required performance limits of pressure with 95% confidence for each temperature and hose length.

A further comparison of the mean pressure at each hose length revealed that at the 0.05 level of significance there was a significant difference among the mean pressures at three of the hose lengths, i.e., one-half ft, 5 ft, and 15 ft, and no significant differences among the mean pressures at 10 ft of hose.

*Based on binomial distribution for lower one-sided estimate.

TABLE XI.
Statistical Analysis of Pressure

Temperature (°F)	Hose Length (ft)	Sample Size	Pressure ($lb/in.^2$) Mean	Standard Deviation	Required Limits Lower	Required Limits Upper	No. Failing to Meet Requirements	Reliabiltiy[a] (%)
-65	0.5	5	5617	106.34	1000	8000	0	99.99
-65	5	5	3079	60.56	1000	8000	0	99.99
-65	10	5	2135	113.36	1000	8000	0	99.99
-65	15	20	1557	92.66	1000	8000	0	99.99
+70	0.5	5	5739	156.42	1000	8000	0	99.99
+70	5	5	3287	61.20	1000	8000	0	99.99
+70	10	5	2318	109.41	1000	8000	0	99.99
+70	15	5	1604	93.10	1000	8000	0	99.6
+200	0.5	20	5785	85.94	1000	8000	0	99.99
+200	5	5	3365	179.16	1000	8000	0	99.99
+200	10	5	2240	167.67	1000	8000	0	99.5
+200	15	5	1834	94.43	1000	8000	0	99.9

[a]Reliability to meet required limits at 95% confidence (two-sided): the estimated proportion of individual items of the population expected to perform within the required limits for pressure.

TABLE XII.
Statistical Analysis of Time to Maximum Pressure

Temperature (°F)	Hose Length (ft)	Sample Size	Time (sec) Mean	Time (sec) Standard Deviation
-65	0.5	5	0.0382	0.0008
-65	5	5	0.0438	0.0011
-65	10	5	0.0376	0.0022
-65	15	20	0.0369	0.0051
+70	0.5	5	0.0386	0.0021
+70	5	5	0.0408	0.0013
+70	10	5	0.0380	0.0022
+70	15	5	0.0342	0.0049
+200	0.5	20	0.0346	0.0026
+200	5	5	0.0374	0.0013
+200	10	5	0.0370	0.0014
+200	15	5	0.0318	0.0024

A comparative study was also performed to determine if the qualification test performance firings and the environmental firings were significantly different. The study showed there was no significant difference at the 0.05 level between the qualification results and the envrionmental firing for mean pressures and time to maximum pressure at -65° F and 15 ft of hose, and +200° F and 0.5 ft of hose.

CONCLUSIONS

Test results obtained during this program have demonstrated the XM273 cartridge, when inserted in the XM100 initiator, will generate sufficient pressure to satisfy a variety of hose lengths and temperature conditions. It was concluded from the qualification results that the performance of the initiator was satisfactory and conformed to all design requirements.

RECOMMENDATIONS

It is recommended that

1. The XM100 initiator be standardized.

2. All initiators be examined with the possibility of incorporating many of the XM100 initiator design improvements for overall simplification.

3. Consideration be given to scaling down the size of the firing mechanism to accommodate the existing primer.

APPENDIX I

DESIGN REQUIREMENTS FOR INITIATOR, CARTRIDGE ACTUATED. XM100

1. Scope

This specification describes the military requirements and characteristics of an improved initiator whose performance will permit its use with short lengths of Teflon hose.

2. Applicable Specifications & Drawings

2.1 Specifications

MIL-C-25918	- "Cartridge Actuated Devices, Aircraft Crew, Emergency Escape, General Specification for"
MIL-STD-810	- "Environmental Test Methods for Aerospace and Ground Equipment"
MIL-A-8625A	- "Anodic Coatings, for Aluminum and Aluminum Alloys"
QQ-P-416	- "Plating, Cadmium (Electrodeposited)"
MIL-P-5514B	- "Packings: Installation and Gland Design of Aircraft, Hydraulic and Pneumatic, General Specification for"

2.2 Drawings

Drawings will be prepared in accordance with MIL-D-1000 - "Drawings, Engineering, and Associated Lists."

3. General Requirements

3.1 Assembly and Disassembly

3.1.1 - The initiator shall be designed so that there will be 100 percent interchangeability of the components.

3.1.2 - The initiator design shall permit rapid and safe disassembly and reassembly without damage to the components. Operation after assembly shall not be dependent upon selective fit of any component.

3.1.3 - - All initiator parts shall be designed to prevent assembly that may produce a malfunction.

3.2 Locking Requirements

3.2.1. - The final assembly of the initiator shall be secured by a method which will prevent inadvertent disassembly during installation or under any condition to which the initiator may be subjected. The method of securing the assembly shall not contribute to the damage of components during disassembly of the initiator.

3.2.2 - The fastening arrangement used to secure external parts shall withstand a breakaway torque of 400 inch-pounds minimum. The fastening arrangement for internal parts shall withstand the vibration test without loosening.

3.2.3 - The locking procedure to fasten the initiator to the mount or to a bulkhead shall be as follows. After locating the safety pin in the desired direction, the locking tabs are to be bent over the mount and the locking nut. For bulkhead mounting, a hole 3/16 in. dia. by 3/16 in. deep is drilled into the bulkhead and a tab is bent into the hole and over the lock nut.

3.3 Locked-shut Firing

The initiator shall withstand the internal pressure developed upon firing locked shut (end fitting capped) through the temperature range of -65° to +200° F without ruptures or failures which would endanger personnel because of shrapnel, flame, etc.

3.4 Environmental Requirements

The initiator shall meet the environmental requirements of MIL-STD-810, using the following table:

Test	Method	Units Required	Remarks
Shock	516 - Procedure 1	6	Note 6.1
Temperature-Altitude-Humidity	518 - Procedure 1	6	Note 6.2 (After 5 cycles, maintain temperature of 70° F for two days; then conduct five more cycles before removing).
Temperature Shock	503 - Procedure 1	6	
Low Temperature	502 - Procedure 1	6	
Vibration	Aircraft category table 514 - Procedure 1, Parts 1, 2, 3; curve D	6	Resonant and cycling period shall be divided equally among -65° F, 70° F, and 200° F.
Salt Fog	509 - Procedure 1	6	
Sand and Dust	510 - Procedure 1	6	Use 200° F in lieu of 160° F.
High Temperature	501 - Procedure 1	6	Use 200° F in lieu of 160° F.
Six-foot Drop	See Remarks	3 w/inert cartridges	Note 6.3.

3.5 Reliability

The initiator shall have a performance reliability of not less than 3 sigma based on a confidence level of 95 percent; that is, the initiator shall have a performance such that the maximum and minimum specification performance requirements for each parameter over the temperature range of -65° to +200° F shall not be exceeded when three times the standard deviation (3 sigma) is added to and subtracted from the average performance value (arithmetical average) as computed from actual firing data. Reported data for each parameter at each condition of temperature must be used for these calculations.

3.6 Firing Mechanism

3.6.1 - The energy of the firing pin when it strikes the primer shall be 120 inch-ounces (minimum).

3.6.2 - The firing mechanism shall be manually operated to function a percussion type primer.

3.6.3 - The pull force required to operate the firing pin shall be 35 to 45 pounds.

3.6.4 - The firing pin must not be released when the initiator is dropped six feet upon either end on a solid concrete surface with the point of impact normal to the axis of the firing pin.

3.7 Cartridge Seal

The modified cartridge shall incorporate a seal adequate to withstand a 14 psi differential pressure cycling test and shall be designed to have a minimum service life of three years.

3.8 Materials

Materials specified for this initiator must have been approved as suitable for the production of aircraft parts.

3.9 Workmanship

The workmanship on all parts shall be governed by the design requirements as set forth on the detailed and assembly drawings, and shall conform to high grade aeronautical practice.

3.10 Magnetism

The initiator shall satisfactorily comply with the test specified in AMC Manual 74-15, Section 4, Paragraph 5.

4. Safety Requirements

4.1.1 - The initiator shall be provided with a ground safety wire for shipping, storage, handling, and maintenance purposes. With the safety pin installed, the initiator pin of the assembled initiator shall not withdraw beyond the safety pin when subjected to an axial load of 200 to 220 pounds. Application of the above load shall cause no deformation of the safety pin.

4.2 Ballistic Requirements

4.2.1 - The pressure measured with an 0.062 cubic inch block at the end of a #4 Teflon hose varying from 6 inches to 15 feet in length shall not exceed 8000 psi and shall not be less than 1000 psi through temperature range of -65° to +200° F.

4.2.2 - The ignition delay shall not exceed 65 milliseconds over the temperature range of -65° to +200° F.

5. Markings

The assembled initiator shall be clearly indentified as follows:

Initiator, Cartridge Actuated, XM100

Lot No. ________________ Serial No. ____________

Loaded with Cartridge ____________________

Cartridge Lot No. ____________

Cartridge Serial No. ________________

Cartridge Loaded Date________________

6. Notes

6.1 The six loaded assemblies will be subjected to all environment tests except drop test.

6.2 Fifteen additional cartridges are exposed to the same test.

6.3 Drop onto a two inch-thick steel plate embedded in concrete; two units are dropped, once on each end (four drops). One unit is dropped twice with longitudinal axis parallel to steel plate.

APPENDIX II

ENGINEERING DESIGN TEST DATA

Round No.	Firing Temperature (°F)	Hose Length (ft)	Max Pressure (psig)	Time to Max Pressure (sec)
1	-65	15.0	1560	0.037
2	-65	15.0	1520	0.035
3	-65	15.0	1445	0.040
4	-65	15.0	1420	0.033
5	-65	15.0	1570	0.044
6	-65	15.0	1700	0.034
7	-65	15.0	1650	0.045
8	-65	15.0	1510	0.033
9	-65	15.0	1450	0.044
10	-65	15.0	1830	0.038
11	-65	15.0	1545	0.030
12	-65	15.0	1510	0.035
13	-65	15.0	1595	0.042
14	-65	15.0	1515	0.035
15	-65	15.0	1530	0.047
16	200	0.5	5900	0.034
17	200	0.5	5870	0.035
18	200	0.5	5680	0.044
19	200	0.5	5785	0.034
20	200	0.5	5670	0.034
21	200	0.5	5720	0.037
22	200	0.5	5710	0.034
23	200	0.5	5795	0.038
24	200	0.5	5860	0.034
25	200	0.5	5890	0.036
26	70	15.0	1685	0.034
27	70	15.0	1705	0.035
28	70	15.0	1610	0.030
29	70	15.0	1500	0.042
30	70	15.0	1520	0.030
31	70	0.5	5635	0.039
32	70	0.5	5845	0.040
33	70	0.5	5660	0.039
34	70	0.5	5595	0.040
35	70	0.5	5960	0.035

NOTE: Time to maximum pressure is elapsed time from first continuous rise on pressure-time trace to point of maximum pressure.

APPENDIX III

QUALIFICATION PERFORMANCE TEST[a] DATA

Round No.	Firing Temperature (°F)	Hose Length (ft)	Max Pressure (psig)	Time to Max Pressure (sec)
1	-65	15.0	1555	0.034
2	-65	15.0	1515	0.036
3	-65	15.0	1545	0.029
4	-65	15.0	1545	0.035
5	-65	15.0	1625	0.033
6	-65	10.0	2065	0.034
7	-65	10.0	2175	0.038
8	-65	10.0	2035	0.040
9	-65	10.0	2315	0.038
10	-65	10.0	2085	0.038
11	-65	5.0	3100	0.042
12	-65	5.0	3125	0.044
13	-65	5.0	3125	0.044
14	-65	5.0	2980	0.045
15	-65	5.0	3065	0.044
16	-65	0.5	5460	0.038
17	-65	0.5	5575	0.039
18	-65	0.5	5740	0.039
19	-65	0.5	5635	0.038
20	-65	0.5	5675	0.037
21	70	10.0	2215	0.041
22	70	10.0	2300	0.037
23	70	10.0	2405	0.039
24	70	10.0	2215	0.038
25	70	10.0	2455	0.035
26	70	5.0	3270	0.040
27	70	5.0	3390	0.041
28	70	5.0	3235	0.039
29	70	5.0	3250	0.042
30	70	5.0	3290	0.042

Round No.	Firing Temperature (°F)	Hose Length (ft)	Max Pressure (psig)	Time to Max Pressure (sec)
31	200	15.0	1945	0.033
32	200	15.0	1900	0.031
33	200	15.0	1745	0.034
34	200	15.0	1730	0.028
35	200	15.0	1850	0.033
36	200	10.0	2055	0.030
37	200	10.0	2270	0.035
38	200	10.0	2080	0.037
39	200	10.0	2430	0.038
40	200	10.0	2365	0.038
41	200	5.0	3340	0.038
42	200	5.0	3160	0.038
43	200	5.0	3640	0.035
44	200	5.0	3410	0.038
45	200	5.0	3275	0.038
46	200	0.5	5695	0.034
47	200	0.5	5895	0.034
48	200	0.5	5820	0.033
49	200	0.5	5875	0.034
50	200	0.5	5830	0.032
51	200	0.5	5790	0.033
52	200	0.5	5790	0.033
53	200	0.5	5790	0.034
54	200	0.5	5665	0.033
55	200	0.5	5675	0.034

[a] All tests conducted with No. 4 Teflon hose into an 0.062 in.[3] pressure block.

[b] Time to maximum pressure is elapsed time from first continuous rise on pressure-time trace to point of maximum pressure.

APPENDIX IV

SAFETY STATEMENT FOR INITIATOR, XM100

1. Observations:

a. The Safety Snap Ring is coated with red plastic, and when it is in place the unit cannot be armed.

b. With the Safety Snap Ring not in place and the shoulder of the Lanyard Pin Flush with the body, it can be armed and fired.

c. With the Safety Snap Ring not in place and the Lanyard Pin removed, and if the unit has not been fired, it cannot be fired or rearmed without disassembly.

d. A fired unit cannot inadvertently be placed into a system because the Lanyard Pin cannot be reinserted unless unit is disassembled.

2. Handling Recommendations:

a. Assembly, disassembly, and test firings to be performed by qualified personnel.

b. Assembly and disassembly procedures as outlined in Appendix V instructions are to be followed precisely.

c. After assembly of the firing mechanism, the Safety Snap Ring is to be inserted and kept in place until time of firing.

d. If the XM100 initiator does not function when the firing pin is actuated, wait a minimum of five minutes before disassembling.

e. Storage and handling shall be in accordance with existing regulations of Quantity Distance, Class 1, Storage Compatibility, Group B, governing explosives.

f. Careful and intelligent handling of the XM100 initiator should be exercised as this unit contains propellant.

Additional Information

Since this unit is basically identical with the M27-type initiator, thousands of which have been acceptance tested and installed in operational systems, it is established as having maximum safety features incorporated. Thus, no unusual or specific maintenance and operational instructions beyond this document and the instructions for assembly and disassembly are deemed necessary.

APPENDIX V

INSTRUCTIONS FOR ASSEMBLY AND DISASSEMBLY OF THE XM100 INITIATOR

A. Assembly of XM100 Initiator

1. Subassembly of Firing Head

a. Parts Required
Initiator Cap, Dwg SFC 13390
Seal, Dwg SFA 32464
Initiator Spring, Dwg SFA 32463
Firing Pin, Dwg SFB 54005
Lanyard Pin, Dwg SFB 54003
Safety Snap Ring, Dwg SFB 54007

b. Inspect all parts for determining that they are free from dirt or grease.

c. Place seal within initiator cap.

d. Insert initiator spring and firing pin.

e. Insert lanyard pin and depress firing pin until lanyard pin engages locking notch. Slowly release pressure upon firing pin until lanyard pin is seated.

f. Insert safety snap ring.

g. Firing head is now assembled.

2. Subassembly of Initiator Chamber

a. Parts Required
Initiator Chamber, Dwg SFC 13391
Initiator Insert, Dwg SFB 54006
Cartridge, Dwg D10551739

b. Place insert within chamber (press fit) until fully seated into the counterbored vent hole.

c. Prior to assembly with firing head, coat outer threads of chamber with "Locktite Sealant," grade A, viscosity (centipoise) 10-15.

d. Insert cartridge.

3. General Assembly

a. Parts Required:
Firing Head Subassembly
Initiator Chamber Subassembly
Initiator Mount, Dwg SFC 13392
Lock Nut, Dwg SFB 56252
Lock Washer, Dwg SFA 33169
Firing Pin Guide, Dwg SFB 54005

b. Coat the inside threads of the initiator cap with "Locktite Sealant," grade A.

c. Insert the firing pin guide into the firing head.
NOTE: The countersink must face the firing pin.

d. Screw the initiator subassembly into the subassembly of the firing head and tighten to 300 inch-pounds torque.

e. To complete the assembly, add mount, lock nut, and lock washer.

f. Locking procedure to fasten the initiator to the mount or to a bulkhead shall be as follows. After locating the safety pin in the desired direction, the locking tabs are to be bent over the mount and the locking nut. For bulkhead mounting, a hole 3/16 in. dia by 3/16 in. deep is drilled into the bulkhead and a tab is bent into the hole and over the lock nut.

4. Disassembly of XM100 Initiator (Fired or Unfired Unit)

a. Unscrew the initiator chamber subassembly from the firing head subassembly.

b. Remove cartridge from chamber.

c. With a 5/32 in. steel rod, drive out the initiator insert from the chamber.

d. Take the subassembly of the firing head and remove safety pin, untab the lockwasher, and remove lock nut, lock washer, and mount.

e. Depress firing pin until lanyard pin unlocks and is removed. Slowly release firing pin; remove firing pin and spring.

f. Remove seal.

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13. ABSTRACT

This report describes the development and qualification of the XM100 Initiator. The XM273 Impulse Cartridge is contained in the initiator and, when fired, provides a pressure output of approximately 1500 psig at -65° F with 15 feet of Teflon #4 size hose. The maximum pressure obtained when fired with one-half foot of hose at 200° F is approximately 6000 psig.

The initiator incorporates a simplified firing mechanism that is mechanically actuated. In addition to the normal bulkhead mounting, the initiator has a universal bracket that offers greater flexibility for mounting than designs presently in use.

The qualifiction results established that the XM100 Initiator satisfied all performance requirements and its ballistic characteristics were reproducible with respective hose lengths.

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